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ABSTRACT

Many kinds of individual differences among learners have been studied by psychologists and educators in an attempt to improve the educational process. Some emphasis has been placed on the notion of cognitive style in an effort to understand more of the cognitive processes which underlie academic performance. The purpose of the present study was to investigate the relationship between cognitive style, defined in terms of educational set, and achievement in elementary statistics at the college level. The results suggested that style attributes do account for a significant proportion of the variance in achievement in elementary statistics. (Author)

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THE RELATIONSHIP BETWEEN COGNITIVE STYLE AND THREE TYPES OF ACADEMIC ACHIEVEMENT

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ABSTRACT

Many kinds of individual differences among learners have been studied by psychologists and educators in an attempt to improve the educational process. Some emphasis has been placed on the notion of cognitive style in an effort to understand more of the cognitive processes which underlie academic performance. The purpose of the present study was to investigate the relationship between cognitive style, defined in terms of educational set, and achievement in elementary statistics at the college level. The results suggested that style attributes do account for a significant proportion of the variance in achievement in elementary statistics.

THE RELATIONSHIP BETWEEN COGNITIVE STYLE AND ACADEMIC ACHIEVEMENT

OBJECTIVE

Many kinds of individual differences among learners have been studied by psychologists and educators in an attempt to improve the educational process. Some emphasis has been placed on the notion of cognitive style in an effort to understand more of the cognitive processes which underlie academic performance. Cognitive style refers to stable individual differences in modes of organizing and processing information and experiences (Messick, 1976). The purpose of the present study was to investigate the relationship between cognitive style and academic achievement.

DEFINITIONS

Academic achievement was measured in terms of three types of learning outcomes: factual/comprehension, application, and analysis. These three outcomes were defined as synonymous with the knowledge and comprehension, application, and analysis categories described in Bloom's Taxonomy of Educational Objectives: Cognitive Domain (Bloom, 1956). Knowledge learning implies the recall or recognition of specific elements in a subject area. Comprehension learning requires

students to translate, interpret, and extrapolate from given messages. Application learning is associated with using abstractions in particular and concrete situations. Analysis learning involves "the breakdown of a communication into its constituent parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit" (Bloom et al, 1971).

The cognitive style dimension of concern was defined by Siegel and Siegel (1965) as individual differences in educational set. These investigators have proposed an educational set continuum, ranging from a preference to learn factual material to a preference to learn conceptual material. A polarized factually set student is defined as one who is predisposed to learn unrelated units of information, while a polarized conceptually set student is defined as one who "rejects factual acquisition except as units of information are clustered and related" (Siegel & Siegel, 1965, p.1). The Education Set Scale (ESS) described by Siegel and Siegel (1967) was used to assess a student's relative position on the educational set continuum.

The ESS is a forced choice instrument with 31 triads, each triad having a factual, a neutral, and a conceptual component. Students rank order the triad topics according to which would interest them most and which would interest them least. Their ESS scores are derived from these rankings. Topics used in the ESS include social science, geog-

raphy, busines and economics, government, natural sciences, and English.

The ESS was selected as the cognitive style measure for this study primarily because of its congruence with the cognitive levels of Bloom's taxonomy. At its lowest level, the taxonomy's classification scheme involves tasks associated with the memory of facts; at the highest levels the taxonomy identifies tasks which require higher cognitive processes. Analogously, the ESS defines a style continuum ranging from an affinity for factual learning to an affinity for conceptual learning. The ESS is appealing also because it is easily administered and scored, and has been shown to be a highly reliable instrument based on a sound rationale. The split-half reliability in a sample of 200 college studnets was .94. The test-retest reliability for 66 students over time intervals ranging from one to five days was .92 (Siegel & Siegel, 1965). Since cognitive ability is related to achievement, its effect is controlled for in the analysis so that a clearer view of the unique relationship between cognitive style and academic achievement could be obtained.

RATIONALE

Ausubel's notion of subsumption (1963) leads one to speculate that individuals who exhibit a strong preference for conceptual learning should also be adept at recalling factual material. This facility would be a logical outgrowth of

their tendency to interrelate facts and tie them together in a conceptual framework. As part of such a framework, facts should be retained longer and their significance better understood. In contrast, individuals who exhibit a strong stylistic preference for factual learning must depend upon rote memorization to facilitate recall. Given the phenomenon of forgetting, one might expect the factual learner to acquire facts easily but to forget them more rapidly than do conceptual learners (Siegel & Siegel, 1965).

The use of a conceptually oriented style should be even more efficacious when the student attacks tasks at the higher levels of Bloom's taxonomy. Each level of tasks encompassed by the taxonomy requires the use of higher cognitive processes than the levels below it. Comprehension items require greater use of integrative skills than do knowledge items; application items require still higher processes, and so on through the taxonomy. Therefore, the strength of the linear relationship between ESS and achievement should increase from one level to the next upward through the taxonomy.

SUBJECTS

A total of sixty students enrolled in a course in elementary statistical methods taught at a midwestern university served as subjects. All were unpaid volunteers who were well informed of the purpose and procedures involved in the study.

TESTS

Cognitive Ability Measure

Three different measures of cognitive ability were used in this investigation: (1) Graduate Record Exam (verbal and quantitative) (2) Scholastic Aptitude Test (verbal and quantitative) (3) American College Testing Program scores (verbal and mathematical). All student ability measures were obtained from university records. The GRE score was used when available. If GRE scores were missing, the GRE scores were estimated using the following regression equations provided by Schrader (1967):

Predicted GRE-V = .93(SAT-V) + 63.06

Predicted GRE-Q =1.04(SAT-Q) - 1.45.

When both GRE and SAT scores were missing, SAT scores were estimated from ACT scores using concordance tables provided by Langsten and Watkins (1980). These estimated SAT scores were then used in the above regression equations to predict GRE scores. Thus, each subject had a GRE score whether it be actual or predicted. There were 38 actual GRE scores, another 7 were predicted using SAT alone, and the remaining 15 required both ACT and SAT scores for prediction. Although this estimation procedure is likely to contain considerable measurement error, it was used to maintain the sample size. Two subjects were dropped from the analysis due to missing ability measures.

Achievement Measures

Items for the achievement measures were obtained from multiple choice items on three exams (25-30 items each) administered during the semester as part of the student evaluation process. Three raters were asked to classify each item into one of six taxonomic levels according to Bloom's guidelines. A written outline of the guidelines was supplied to each rater to be used during the classification process.

Of the 82 items rated, all three raters agreed on the classification of 20 items, two of three raters agreed on the classification of another 47 items, and there was no agreement among raters on the remaining 15 items. The no agreement items were then discussed among the three raters as a group. This discussion resulted in agreement on the classification of all 15 items. When two raters agreed on the classification of an item, the third rating was ignored and the item classified according to the majority opinion. A total of 22 knowledge items, 32 comprehension items, 19 application items, and 9 analysis items were used in this investigation. These four tests had respective estimated reliabilities of .77, .81, .71, and .49, using Kuder Richardson formula 8 (Kuder & Richardson, 1937). There were no synthesis nor evaluation items. It was originally intended that all six taxonomic levels be represented. However, the test items commonly used in this course do not measure objectives defined by the higher levels of Bloom's taxonomy.

Because the achievement measures were not equally reliable, it was necessary to demonstrate that the population correlation for each pair of achievement measures, corrected for attenuation, was less than 1.0. If any of these correlations could not be shown to be less than 1.0, this would provide evidence that the two types of test items were measuring essentially the same abilities. It would then be appropriate to combine these two tests into one achievement category. A total of six F-tests, representing all possible pairwise comparisons, were performed using a modified mean square ratio (Forsyth & Feldt, 1970) and the results are presented in Table 1. In each case, the hypothesis tested was that the population correlation coefficient corrected for attenuation equals 1.0. The mean square ratio associated with the test comparing the knowledge and comprehension levels was .62, which is a non-significant result. Therefore, the knowledge and comprehension items were combined and labeld the knowledge/comprehension category. For all other combinations, the hypothesis of complete overlap in abilities could be rejected ($p<.10$). Therefore, the three achievement types were defined as knowledge/ comprehension, application, and analysis. The KR-8 reliability estimate for the knowledge/comprehension test was .88.

PROCEDURES

This investigation was intended to test the foregoing three hypotheses.

1. The cognitive style dimension defined by the ESS is positively related to achievement at each of three levels of Bloom's taxonomy (knowledge/comprehension, application, and analysis), as these levels apply to a college course in elementary statistical methods.
2. This positive, linear relationship holds even after the student's overall level of cognitive ability, as measured by the GRE score (actual or estimated) is partialled out.
3. The partial correlations noted above, corrected for the attenuation resulting from the unreliability in the achievement tests, tend to increase from the lowest to the highest level of Bloom's taxonomy.

The first hypothesis addressed the question of whether the population correlation between ESS and each of the three types of achievement (knowledge/comprehension, application, analysis) was statistically greater than zero. In each case, the Pearson correlation coefficient was computed and the appropriate t-test performed.

To accomplish the goal of the second hypothesis, partial regression coefficients associated with each of the three types of achievement were estimated. These coefficients represent the correlation between ESS and achievement, with GRE being held constant. Next, t-tests were performed on

each of these estimated coefficients to determine if any were significantly greater than zero (Kendall & Stuart, 1973, p. 346).

The next step was to calculate the partial correlations noted above, corrected for the attenuation resulting from the unreliability of the achievement tests. Then, the resulting correlations were observed to see if they tended to increase from the lowest to the highest level of Bloom's taxonomy.

RESULTS and DISCUSSION

The correlations among the achievement tests, ESS, and GRE are presented in Table 2. The means and standard deviations for each variable are also included in this table. The correlations between ESS and each of the three achievement tests (knowledge/comprehension, application, analysis) were .56 ($p<.0001$), .49 ($p<.0001$), and .32 ($p<.01$) respectively. These results support the first hypothesis that cognitive style is positively related to these three types of achievement.

Table 3 presents the standardized partial regression coefficients associated with each type of achievement measure, and also the corresponding t-statistic for each. These coefficients represent the correlation between ESS and each particular achievement measure, with the effect of GRE being held constant. As noted in Table 3, all three regres-

sion coefficients are significant at the .01 level or beyond. Therefore, the second hypothesis, that the positive relationship between ESS and the achievement measures will hold after controlling for GRE, was supported.

The third hypothesis stated that the partial correlations, when corrected for the attenuation resulting from the unreliability in the achievement tests, tend to increase from the lowest to the highest level of Bloom's taxonomy. This hypothesis was not supported. The corrected partial correlations for the knowledge/comprehension, application and analysis achievement tests were .46, .42, and .39, respectively. The logical next step would be to test whether these corrected partials are different from one another. However, since all are essentially equal to each other, this test would be of little practical importance.

The results of this study indicate a positive relationship between cognitive style, as measured by ESS, and three types of achievement (knowledge/comprehension, application, and analysis). The strength of this relationship, however, is essentially equal at all three levels. Thus, the learning advantage of students who exhibit a strong preference for conceptual material, apparently, does not change over the three achievement levels. This result is surprising since each successive level, according to Bloom's taxonomy, requires the use of higher cognitive processes than do the levels below it. It should be noted, however, that the ESS

was designed to measure one's preference for a particular type of material, not one's ability to sucessfully deal with that material. Therefore, it is possible for one to have a strong preference for conceptual learning yet be incapable of high performance with tasks which require the use of higher cognitive processes.

Further insight into the relationship between ESS and achievement might be found in the distribution of ESS scores. The ESS may be viewed as a continuum ranging from a preference to learn factual material to a preference to learn conceptual material. High negative scores suggest a strong preference for factual material, and high positive scores suggest a strong preference for conceptual material. Strictly speaking, the extreme factually-set individual and the extreme conceptually-set individual are located at opposite poles of the educational set continuum. Inspection of Table 2 reveals that the mean of the ESS scores was 17.0 with a standard deviation of 12.8. The scores ranged from -9 to +41. A closer look at these scores showed that only five of the sixty subjects had a negative ESS score. The sample, therefore, contained virtually no students who expressed a strong preference to learn factual material.

It had been anticipated that the strength of the relationship between ESS and achievement would increase from one level to the next upward through Bloom's taxonomy. However, since the range of ESS scores was based upon virtually all

conceptually oriented students, the true relationship between these variables may have been obscured. If the true relationship is to be uncovered, subsequent investigations should include samples which contain more factually oriented subjects.

Another possible explanation for the unexpected results may stem from the use of the Kuder Richardson (1937) formula 8 to estimate the reliabilities of the achievement subtests. These reliability estimates for the knowledge, comprehension, application, and analysis tests were .77, .81, .71 and .49, respectively. The K-R 8 formula typically yields higher reliability estimates than does the more commonly used K-R 20 formula (Kuder & Richardson, 1937). The largest differences occur when the number of items on a particular test is small. There were a total of 22 knowledge items, 32 comprehension items, 19 application items, and 9 analysis items. Table 1 presents the correlations among the four subtests, corrected for the attenuation resulting from their unreliability.

It is obvious from Table 1 that the corrected correlations for the analysis measure are considerably lower than the others. Every corrected correlation which does not involve the analysis items is reasonably close to 1.0. If the subtest reliability estimates are inflated due to the use of the K-R 8 formula, the analysis test reliability estimate is likely to have been inflated the most, since it includes the

smallest number of items. Recall that correlations corrected for attenuation are inversely related to the product of the square root of the reliability estimates of the tests involved. Thus, the use of higher reliability estimates (e.g. K-R 8 estimates) in the attenuation formula result in lower corrected correlations. Therefore, if K-R 20, rather than K-R 8, reliability estimates had been used in this study, the corrected correlations involving the analysis test would probably have been very much higher, and those not involving the analysis test would probably have been slightly higher. As a result, it might have been concluded that the abilities measured by the different types of test items overlapped to a greater extent than that suggested by the correlations in Table 1. With only one level of achievement involved, an hypothesis about differential strengths of the relationship between ESS and achievement defined in terms of Bloom's taxonomy would be meaningless. An appropriate test of this hypothesis would require a fairly large number of test items which evaluate the skills at only one taxonomic level. The unique variance component for the several achievement measures would have to be considerable.

Educational set is potentially useful in adapting educational environments to meet the idiosyncratic needs of students. Since conceptually set students may have a learning advantage at the college level, an argument can be made for attempting to alter a student's educational set in that di-

rection. This argument would be valid of course, only if a causal relationship is first established between educational set and academic achievement. If educational set, subsequently, is shown to be resistant to change, it might be wise to impose educational goals on students that are congruent with their educational sets. In addition, educational set may be helpful in predicting school learning outcomes and understanding the relationships among cognitive style, ability, and academic achievement.

SUMMARY

This study failed to confirm the hypothesis that the style attributes, as measured by the ESS, assume progressively greater importance from the lowest to the highest levels of achievement within the Bloom taxonomy. The data suggested that style attributes do account for a small proportion of the variance in achievement in elementary statistics. That proportion of variance is not demonstrably different, however, for the categories labeled knowledge/comprehension, application, and analysis.

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TABLE 1

Correlations among four achievement tests,
corrected for the attenuation resulting from their unreliability

N=60	Know	Comp	Appl	Anal
Knowledge	1.00			
Comprehension	1.00 (.62)	1.00		
Application	.86 (1.85)**	.95 (1.34)*	1.00	
Analysis	.57 (2.26)**	.57 (2.39)**	.54 (2.29)**	1.00

Note: Corrected mean square ratios (see Forsyth & Feldt, 1970), for test that the population correlation coefficient corrected for attenuation equals 1.0, are in parenthesis, (d.f. = 59, 118).
** p<.01
* p<.10

TABLE 2

Correlations among Achievement Tests, ESS, and GRE

	Kno/Comp	Appl	Anal	ESS	GRE
Knowledge/Comprehension	.88				
ApPlication	.71	.71			
Analysis	.37	.32	.49		
ESS	.56**	.49**	.32*		
GRE	.58	.56	.18	.44	
Mean	34.6	11.7	3.5	17.0	1025.7
Std.Deviation	8.9	3.2	1.5	12.8	192.2
N	60	60	60	60	60

NOTE: Reliability estimates for the achievement tests appear on the diagonal.

** p<.0001
* p<.01

TABLE 3

Standardized partial regression coefficients
b(Ach ESS.GRE) with associated t-statistics

b(K/C ESS.GRE) = .41	df=57	t=4.14	p<.0001
b(App ESS.GRE) = .36	df=57	t=3.24	p<.001
b(Ana ESS.GRE) = .33	df=57	t=2.46	p<.01

Note: A standardized partial regression coefficient represents the correlation between a particular achievement measure and ESS, with GRE being held constant.

Note: K/C = Knowledge/Comprehension
App = Application
Ana = Analysis
Ach = Achievement